# Space Weather Technical Forecast

Issued on Friday, 04 March 2022 at 13:07 Local

**This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales**

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**Space Weather Forecast Headline: Chance of G1/Minor Geomagnetic Storms. Slightly increasing chance of R1 Minor Radio Blackouts.**

**Analysis of Space Weather Activity over past 24 hours**

**Solar Activity:** Solar activity was Low over the period, with isolated C-class flares, the largest of which was a long duration C3.3 which peaked at 03/2155 UTC. This flare originated from the small and innocuous AR2958, which was a Bxo/beta classification, but has since faded from the visible disc. There are currently six numbered sunspot regions on the visible disc; AR2954 and 2955 remain simple, mature and stable nearing the western solar horizon, with 2954 soon rotating off disc. AR2957 has increased slightly, with developing more intermediate spots. AR2960 is now the largest and most complex region on the visible disc, which has developed some intermediate spots, one of which has consolidated into the leading spot. This region is currently classified as a Eai/beta, although this will continue to be monitored for any further developments as it continues to rotate onto the visible disc. In addition a plage region has rotated onto the northeast limb, with flux loops showing in AIA 171 imagery indicating some complexity and energy available, despite the lack of visible spots. The long duration C3.3 flare may have produced a Coronal Mass Ejection (CME), which potentially could have an Earth directed element. However, currently there is no evidence of a CME in available imagery to verify this possibility.

**Solar Wind / Geomagnetic Activity:** The solar wind as measured by DSCOVR at L1 started the period at background levels, around 380km/s, before increasing to slightly elevated levels, currently near 480km/s, possibly due to Earth entering into a fast wind from CH61. The solar wind density was mainly at average levels, with a slight increase to above average, with a peak of 23ppcc at 03/1630UTC, before decreasing back to average levels. The phi angle started the period positive (away from the sun), then switched to become mostly negative (towards the sun) from 03/1630UTC, with some slight variations in the orientation. The IMF was generally weak to moderate throughout, with a peak of 9nT at 04/0040UTC. The north-south component (Bz) was also weak to moderate, ranging between +8 and -5nT. The subtle changes in the solar wind environment indicated the possible arrival of a CIR from a high speed stream from CH61. However, geomagnetic activity remained Quiet (Kp 0-2) throughout.

**Energetic Particles / Solar Radiation:** The high energy proton flux (10 MeV) measured at GOES 16 was at Normal Background levels. The high energy electron flux (greater than 2 MeV) was at background to moderate levels, peaking at 418 pfu at 03/1750 UTC. The corresponding 24-hour integrated electron fluence remained well below the Active (1e8 integrated pfu) threshold, although with an increasing trend later in the day. The 04/0000 UTC observation was 5.44e6 integrated pfu.

**Four-Day Space Weather Forecast Summary**

**Solar Activity:** Solar activity is likely to be Low, with occasional C-class flares and a chance of M-class flares. No significant regions are expected to rotate onto the visible disc from the far

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side through the period.

**Solar Wind / Geomagnetic Activity:** Through the period Earth is likely to experience a negative polarity high speed stream (HSS) from CH61, quickly followed by a HSS from CH62. A CME, emitted on 2nd March in association with the M-class flare, may brush Earth on day 3 (6th). Geomagnetic activity is expected to be Quiet to Unsettled at first (Kp 2-3), increasing Unsettled to Active (Kp 3-4) today and then at times through the rest of the period, with a chance of isolated G1/Minor geomagnetic storm (Kp 5) intervals.

**Energetic Particles / Solar Radiation:** The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels.

The high energy electron flux and fluence is expected to remain at background to moderate levels today and tomorrow, then increasing to predominantly moderate levels, with occasional breaches of the high level (1000 pfu) possible at the peaks of the diurnal cycles, during days 3 and 4 (6th and 7th). However, confidence is low regarding this, as flux levels may be tempered by any CME arrival. The corresponding fluence is expected to show an increasing trend, whilst persisting below the Active (1e8 integrated flux) threshold.

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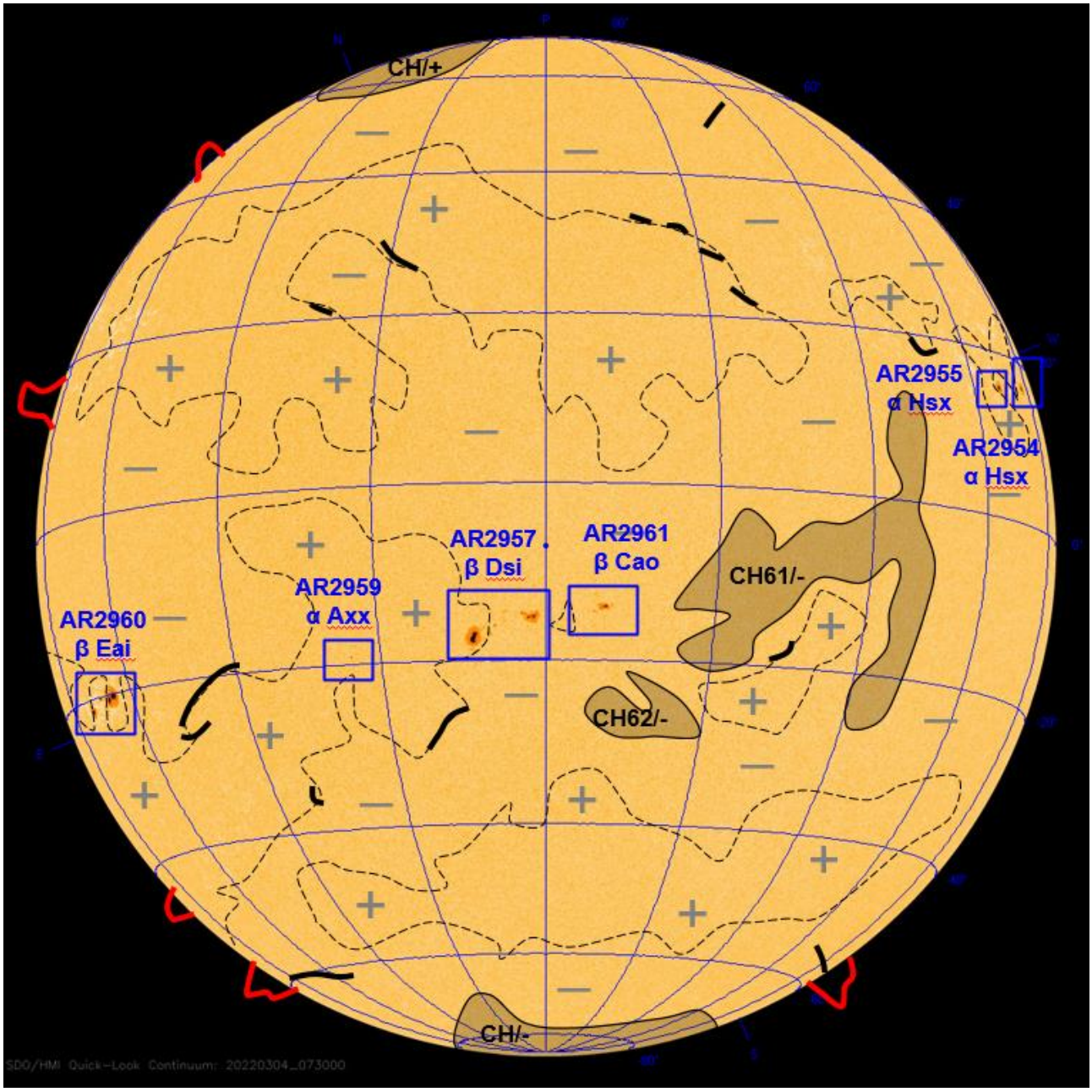
**Figure 1. Solar Analysis Valid 04/0730UTC.**




**Key:** Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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## Geomagnetic Storms:

There are two main aspects of the geomagnetic forecast - firstly a high speed stream (HSS) from CH61 quickly followed by a HSS from CH62; and secondly possible marginal effects from the 02/1739UTC M2.0 CME that should mainly pass behind the Earth in the track of its orbit. Despite CH61/- and CH62/- being present on the previous rotation, a CME also occurred around 27 days ago which contaminated the persistence data. Earth is currently in a high speed stream from CH61, which is evident in recent DSCOVR L1 data, with recent changes in the solar wind parameters, which indicated the arrival of a weak CIR ahead of the HSS from CH61 yesterday evening. Solar winds are currently slightly elevated, near 480km/s, with a steady rising trend. Wind speeds are expected to reach around 500km/s as indicated by STEREO-A data. Being near the vernal equinox, these negative coronal hole features make a G1/Minor geomagnetic storm possible.

Modelling of the 02/1739UTC M2.0 CME revealed some MOSWOC Enlil ensemble members with 'hits' on or after 06/1200UTC, however closer inspection of their perturbations suggests that these are not favoured scenarios (e.g. excessively wide CME cone angles - compared to observed imagery). In any case, with this CME thought to be more fully aimed at STEREO A. Therefore confidence is low regarding the possible glancing blow of the CME at Earth on day 3 (6th).

| Geo-Magnetic Storm Probability (Exceedance) | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| Minor or Moderate | G1 to G2 | No | 40 | 30 | 40 | 20 |
| Strong | G3 | No | 1 | 1 | 1 | 1 |
| Severe | G4 | No | 1 | 1 | 1 | 1 |
| Extreme | G5 | No | 1 | 1 | 1 | 1 |

## Geomagnetic Activity - Earthbound Coronal Mass Ejections

| Date/time 21.5R (UTC) | Halo: Full or Partial | Source | Source Location | Estimated Speed | Estimated Arrival Time | Comments |
|---|---|---|---|---|---|---|
| 2022-03-03 06:01 UTC | Possible partial | AR2958 | NE quadrant N05E039 | 270km/s | After 06/1200UTC | Mainly behind Earth in orbit, low confidence in glancing blow. |

**Figure 2: ENLIL model (top) and ENLILs ensemble runs (bottom) which shows the potential glancing blow of a CME on the 6th March – possibly early on the 7th March.**

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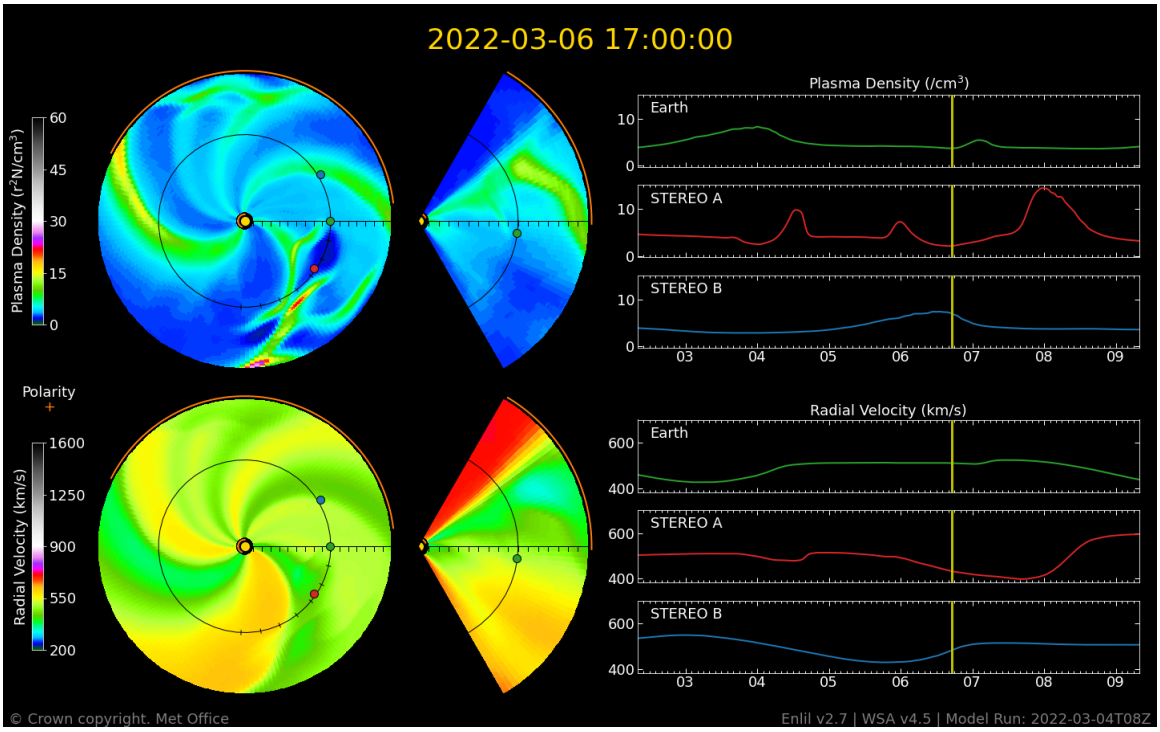
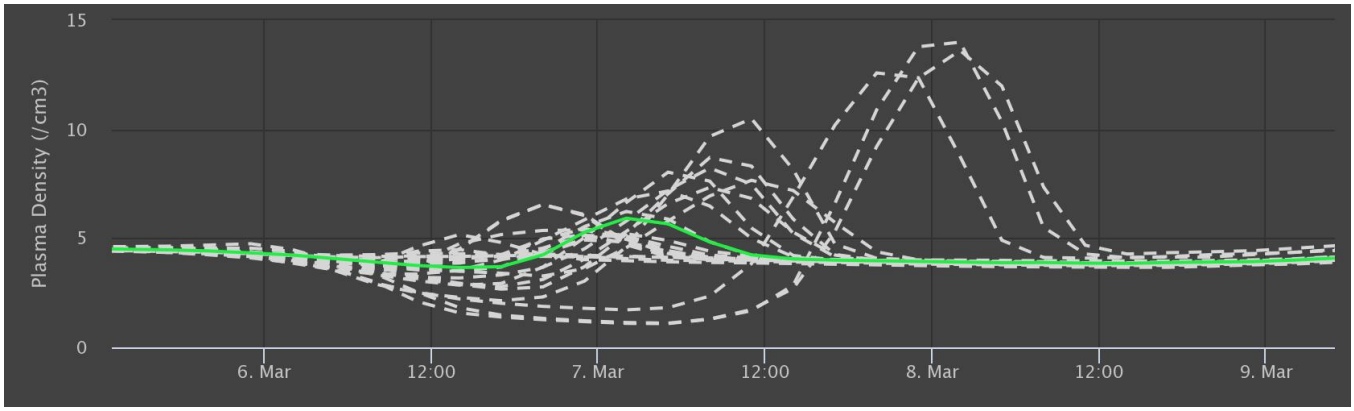
# Space Weather Technical Forecast

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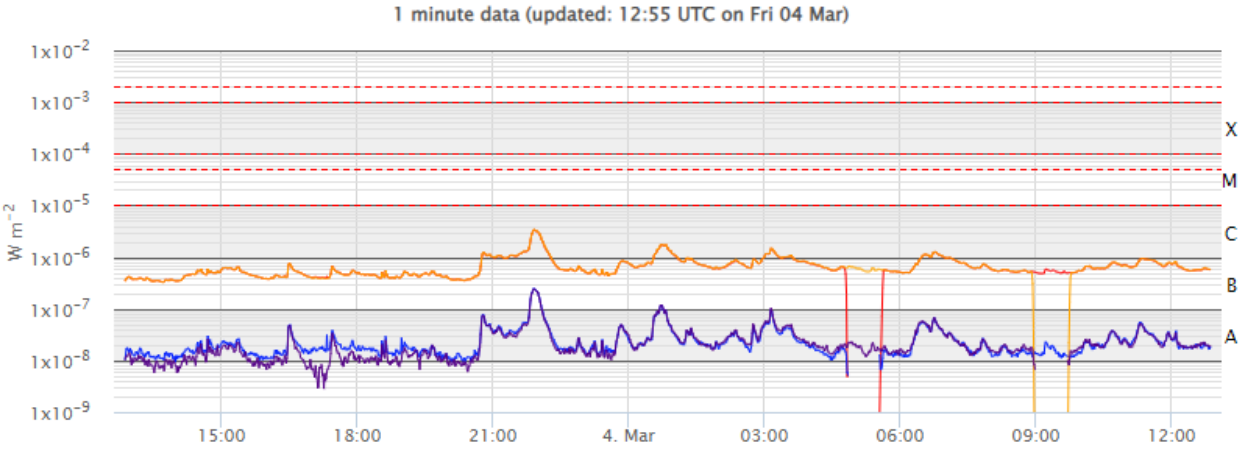
**Radio Blackouts - X-Ray Flares:**
There are six numbered regions on the disc. AR2958 has now faded from the visible disc, although before it disappeared this region, which appeared to be a small and innocuous Bxo/beta classification, was the origin for the long duration C3.3 flare, which peaked at 03/2155UTC. There are currently six sunspot regions on the visible disc; AR2954 and AR2955 remain simple, mature and stable nearing the western solar horizon, with AR2954 soon rotating off the visible disc. AR2957 has increased slightly, with more intermediate spots developing. This region is currently classified as a Dsi/beta. AR2960 is now the largest and most complex region on the visible disc, which has also developed some intermediate spots, one of which has consolidated into the leading spot. This region is currently classified as a Eai/beta, although this will continue to be monitored for any further developments as it continues to rotate onto the visible disc. In addition a plage region has rotated onto the northeast limb, with flux loops showing in AIA 171 imagery indicating some complexity and energy available, despite the lack of visible spots in current imagery. There is Likely to be further daily C-class flares, with a Chance of M-class flares.

| X Ray Flares | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) | Day 2 (00-24 UTC) | Day 3 (00-24 UTC) | Day 4 (00-24 UTC) |
|---|---|---|---|---|---|---|
| Probability | | | (%) | (%) | (%) | (%) |
| Active | R1-R2 M Class | No | 20 | 20 | 20 | 20 |
| Very Active | R3 to R5 X Class | No | 1 | 1 | 1 | 1 |

**Figure 3: GOES-16 X-Ray flares.**

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## Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (10MeV) measured at GOES 16 is currently at background levels. The slightly increasing trend in the probabilities indicates the rotation of AR2960 further west across the visible disc, and so into slightly more geo-effective positions. However, overall the high energy proton flux (10MeV) is expected to remain at background levels.

| Radiation Storms Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $s^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ S1** | No | 2 | 3 | 5 | 5 |
| **Very Active** | **≥ S3 *** | No | 1 | 1 | 1 | 1 |

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

## High Energy Electrons Event (≥ 2MeV):

The high energy electron flux (greater than 2 MeV) has been at background to moderate levels during the past 24 hours, with background to slightly elevated solar wind speeds. Through much of the period HSS from coronal hole features are expected to reach Earth, maintaining slightly elevated winds for much of the time.

The high energy electron flux and fluence is expected to remain at background to moderate levels today and tomorrow, then increasing to predominantly moderate levels, with occasional breaches of the high level (1000 pfu) possible at the peaks of the diurnal cycles, during days 3 and 4 (6th and 7th). However, confidence is low regarding this, as flux levels may be tempered by any CME arrival. The corresponding fluence is expected to show an increasing trend, whilst persisting below the Active (1e8 integrated flux) threshold. The Met Office REFM model is therefore considered to be offering good guidance.

| GEO Electron Environment Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $day^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ 2 MeV ≥ $1x10^8$** | No | 10 | 20 | 30 | 40 |
| **Very Active** | **≥ 2 MeV ≥ $1x10^9$** | No | 1 | 1 | 1 | 1 |

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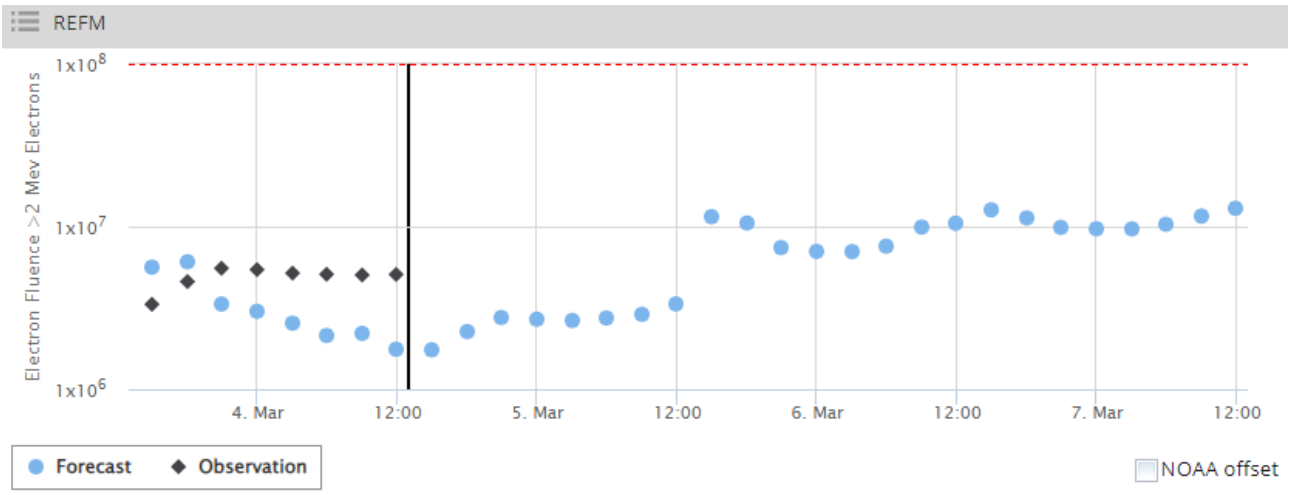
**Figure 4: Met Office REFM model.**



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